The Meaning and Limits of Exact Science

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EXACT SCIENCE—what wealth of connotation these two words have! They conjure up a vision of a lofty structure, of imperishable slabs of stone firmly joined together, treasure-house of all wisdom, symbol and promise of the coveted goal for a human race thirsting for knowledge, longing for the final revelation of truth. And since knowledge always means power, too, with every new insight that man gains into the forces at work in nature, he always opens up also a new gateway to an ultimate mastery over them, to the possibility of harnessing these natural forces and making them obey his every command.

But this is not all—or even the most important part of it. Man wants not only knowledge and power. He wants also a standard, a measure of his actions, a criterion of what is valuable and what is worthless. He wants an ideology and philosophy of life, to assure him of the greatest good on earth—peace of mind. And if religion fails to satisfy his longing, he will seek a substitute in exact science, I refer here merely to the endeavors of Monism, founded by outstanding scholars, philosophers, and natural scientists, a school of thought which commanded high respect only as recently as a short generation ago.

Yet, in these our days hardly a word is being heard about the Monists, although the structure of their ideology was unquestionably erected to endure for a long time to come, and it started out on its career with high hopes and great promises. There must be something wrong somewhere! And in fact, if we take a closer look and scrutinize the edifice of exact science more intently, we must very soon become aware of the fact that it has a dangerously weak point—namely, its very foundation. Its foundation is not braced, reinforced properly, in every direction, so as to enable it to withstand external strains and stresses. In other words, exact science is not built on any principle of such universal validity, and at the same time of such portentous meaning, as to be fit to support the edifice properly. To be sure, exact science relies everywhere on exact measurements and figures, and is therefore fully entitled to bear its proud name, for the laws of logic and mathematics must undoubtedly be regarded as reliable. But even the keenest logic and the most exact mathematical calculation cannot produce a single fruitful result in the absence of a premise of unerring accuracy. Nothing can be gained from nothing.

No phrase has ever engendered more misunderstanding and confusion in the world of scholars than the expression, "science without presuppositions." It was coined originally by Theodor Mommsen, and meant that scientific analysis and research must steer clear of every preconceived opinion. But it could not mean, nor was it intended to, that scientific research needs no presuppositions at all. Scientific thought must link itself to something, and the big question is, *where*. This question has occupied the minds of the most profound thinkers of all epochs and all nations, since time immemorial, from Thales to Hegel, setting in motion all forces of man's imagination and logic. But it has been demonstrated again and again that a final, conclusive answer cannot be found. Perhaps the most impressive proof of this negative finding is that until now all attempts have failed to discover a world view uniformly acceptable, in its general features at least, by all minds capable of judgment. The only conclusion which this fact permits, according to every dictate of reason, is that it is absolutely impossible to place exact science in an a priori manner on a universal foundation possessing a fixed and inclusive content.

Thus, at the very outset of our quest for the meaning of exact science, we are confronted by an obstacle which must be a disappointment to everybody who is seriously striving for knowledge. In fact, this obstacle has driven many a critically disposed thinker to join the ranks of the skeptics. And a no less regrettable fact is that there are perhaps just as many, or even more, individuals of the opposite disposition whom the fear of falling victim to skepticism—an ideology which they consider intolerable—drives to look for salvation from prophets of creeds like, for instance, anthroposophy. Such prophets appear on the scene in all epochs, not excepting our own, with their brand new message of salvation, and they often succeed, with an amazing rapidity, in gathering a following of enthusiastic disciples, eventually to make their exit from the stage and to sink back into the all-engulfing abyss of oblivion.

Is there a way out of this fatal dilemma? And where can it be found? This is the first question to claim our attention. I shall attempt to show that there is a positive answer to it, and that this answer will cast a light both on the meaning and limits of exact science. I submit to the judgment of each of

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you the validity of my proposed resolution of the problem.

I

If we seek a foundation for the edifice of exact science which is capable of withstanding every criticism, we must first of all tone down our demands considerably. We must not expect to succeed at a stroke, by one single lucky idea, in hitting on an axiom of universal validity, to permit us to develop, with exact methods, a complete scientific structure. We must be satisfied initially to discover some form of truth which no skepticism can attack. In other words, we must set our sights not on what we would like to know, but first on what we do know with certainty.

Now then, among all the facts that we do know and can report to each other, which is the one that is absolutely the most certain, the one that is not open even to the most minute doubt? This question admits of but one answer: "That which we experience with our own body." And since exact science deals with the exploration of the outside world, we may immediately go on to say: "They are the impressions we receive in life from the outside world directly through our sense organs, the eyes, ears, etc." If we see, hear, or touch something, it is clearly a given fact which no skeptic can endanger.

To be sure, we speak also of illusions, but never with the intention of implying that the sense perceptions involved are incorrect or even questionable. For instance, when a person happens to be deceived by a mirage, the fault lies not with his perception of the visual image, which is actually present, but in his inferences which draw false conclusions from the given sensory data. The sensory impression is always a given fact, and therefore incontestable. What conclusions the individual attaches to it, are another story, which need not concern us for the time being. Therefore, the content of the sensory impressions is the most suitable and only unassailable foundation on which to build the structure of exact science.

If we call the sum total of sensory impressions "the sense world," we may state briefly that exact science issues from the experienced sense world. The sense world is that which, so to speak, furnishes science with the raw material for its labors.

However, this seems to be a very meager result. For the content of the sense world is, in any case, only something of a subjective character. Every individual has his own senses, and in general, the senses of one individual are quite different from those of another, whereas the aim of exact science is to achieve objective, universally valid knowledge. It may seem, therefore, that in adopting our present approach we have been following the wrong track.

But we must not jump to conclusions. For it will become manifest that considerable progress can be made along the line of advance now open to us. Considered as a whole, the matter reduces itself to the fact that we human beings have no direct access to the knowledge conveyed to us by exact science, but must acquire it one by one, step by step, at the cost of painstaking labors of years and centuries.

Now, if we examine the content of our sense world, it obviously falls apart into as many separate fields as we have sense organs—there is a field corresponding to sight, another to hearing, and still others corresponding to the senses of touch, smell, taste, and heat. These fields are totally different from each other, and have initially nothing in common. There is no immediate, direct bridge between the perception of colors and the perception of sounds. An affinity, such as may be assumed by many art lovers to exist between a certain shade of color and a certain musical pitch, is not directly given, but is the creation, stimulated by personal experiences, of our reflective power of imagination.

Since exact science deals with measurable magnitudes, it is concerned primarily with those sensory impressions which admit of quantitative data—in other words, the world of sight, the world of hearing, and the world of touch. These fields supply science with its raw material for study and research, and science goes to work on it with the tools of a logically, mathematically, and philosophically disciplined reasoning.

II

What, then, is the meaning of this work of science? Briefly put, it consists in the task of introducing order and regularity into the wealth of heterogeneous experiences conveyed by the various fields of the sense world. Under closer examination, this task proves to be fully consistent with the task which we are habitually performing in our lives from our earliest infancy, in order to find our way and place in our environment. This is a task which has kept man busy ever since he first began to think at all in order to be able to hold his own in the struggle for existence. Scientific reasoning does not differ from ordinary everyday thinking in kind, but merely in degree of refinement and accuracy, more or less as the performance of the microscope differs from that of the naked eye. The truth of this statement, and that it must necessarily be so, is evident from the very fact that there is only one kind of logic, and, therefore, even scientific logic cannot deduce anything else from given presuppositions than can the ordinary logic of untrained common sense.

We shall therefore obtain an intuitively clear under-

standing of the results which science achieves through its labors, if we take our point of departure from the experiences known and familiar to us from daily life. If we review our own personal, individual development, and consider the point which our world view has gradually reached in the course of the years, we can say that we are trying to use the facts of experience as the foundation for a unified, comprehensive and practically serviceable picture of the world in which we live; that we conceive the outside world as filled with objects which act on our various sense organs, thus producing our different sensory impressions.

However, since this practical world picture which every human being carries within himself is not a directly given notion, but an idea elaborated gradually on the basis of facts of experience, it is possessed of no final character. It is changed and adjusted by every new datum of experience, from infancy to adulthood, first at a quicker, then at a slower pace. The same principle applies to the scientific world picture. The scientific world picture or the so-called phenomenological world is also not final and constant, but is in a process of constant change and improvement. It differs from the practical world picture of daily life not in kind, but in its finer structure. It is to the world picture of daily life approximately as the world picture of the adult human being is to the world picture of the human child. Therefore the best start toward a correct understanding of the scientific world picture will be to investigate the most primitive world picture, the naive world picture of the child.

Let us, therefore, try to place ourselves as best we can, in the child's mind and world of ideas. As soon as the child begins to think, he begins to form his world picture. For this purpose, he directs his attention toward the impressions which he receives through his sense organs. He tries to classify them, and in this endeavor he makes all kinds of discoveries, such as for instance, that there is a certain orderly interrelation between the inherently different impressions conveyed by the senses of sight, touch, and hearing. If you give the child a toy, let us say, a rattle, he will find that the tactile sensation is always accompanied by a corresponding visual sensation, and as he moves the rattle back and forth, he also perceives a certain regular auditory sensation.

While in this instance the different mutually independent sense worlds appear to be interlocking to a certain degree, on other occasions the child will make an observation which he will find to be no less remarkable—that certain impressions which are completely indistinguishable from one another and have their origin in a common sense world, may nevertheless be of a totally different character. Thus, for instance, the child may look at a round electric light and observe that it looks just like the full moon. The light sensation may be exactly the same. Yet, the child finds a great difference, for he can touch the lamp, but not the moon; he can pass his hand around the lamp, but not around the moon.

What, then, does the child think as he makes these discoveries? First of all, he wonders. This feeling of wonderment is the source and inexhaustible fountainhead of his desire for knowledge. It drives the child irresistibly on to solve the mystery, and if in his attempt he encounters a causal relationship, he will not tire of repeating the same experiment ten times, a hundred times, in order to taste the thrill of discovery over and over again. Thus, by a process of incessant labor from day to day, the child eventually develops his world picture, to the degree needed by him in practical life.

The more the child matures, and the more complete his world picture becomes, the less frequently he finds reason to wonder. And when he has grown up, and his world picture has solidified and taken on a certain form, he accepts this picture as a matter of course and ceases to wonder. Is this because the adult has fully fathomed the correlations and the necessity of the structure of his world picture? Nothing could be more erroneous than this idea. No! The reason why the adult no longer wonders is not because he has solved the riddle of life, but because he has grown accustomed to the laws governing his world picture. But the problem of why these particular laws hold, and no others, remains for him just as amazing and inexplicable as for the child. He who does not comprehend this situation misconstrues its profound significance, and he who has reached the stage where he no longer wonders about anything, merely demonstrates that he has lost the art of reflective reasoning.

Rightly viewed, the real marvel is that we encounter natural laws at all which are the same for men of all races and nations. This is a fact which is by no means a matter of course. And the subsequent marvel is that for the most part these laws have a scope which could not have been anticipated in advance.

Thus, the element of the wondrous in the structure of the world picture increases with the discovery of every new law. This holds true even of scientific research and inquiry in our own day, which continually produce something new. Just think of the mysteries of the cosmic rays, or the mysterious hormones, or the remarkable revelations of the electron microscope. To the research scientist, no less than to the child, it

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is always a gratifying experience and an added stimulus to encounter a new wonder, and he will labor industriously to solve the riddle by repeating the same experiments with his refined instruments just as the child does with his primitive rattle.

However, let us not leap too far ahead, but proceed in an orderly fashion. First, let us investigate in what respect the structure of the child's world differs from the sense world as originally given. The first fact to claim our attention is that sensations, the sole and exclusive constituents of the original world picture, have been driven appreciably into the background. The dominant elements of this world picture are not sensations, but the objects which produce them. The toy is a dominant element, and the tactile, visual, and auditory sensations are merely secondary consequences. But we would not do full justice to the state of affairs were we to say simply that this world picture is nothing but a synthesis of different sensory impressions achieved with the help of the unifying concept of *thing*. For, conversely, a single undifferentiated sense experience may correspond to several different objects. An example of this possibility is the previously mentioned case of an illuminated surface which produces in us a definite sensory impression, and yet is sometimes attributed to an electric light and at other times to the full moon. This is a case of a single undifferentiated sensation which corresponds to two different objects. The contrast, therefore, lies deeper, and can be characterized exhaustively only by introducing the concept of an objectively valid regularity. The sensations produced by objects are private, and vary from one individual to another. But the world picture, the world of objects, is the same for all human beings, and we may say that the transition from the sense world to the world picture amounts to a replacement of a disordered subjective manifold by a constant objective order, of chance by law, and of variable appearance by stable substance.

The world of objects, in contrast to the sense world, is therefore called the "real world." Yet, one must be careful when using the word *real*. It must be taken here in a qualified sense only. For this word has the connotation of something absolutely stable, permanent, immutable, whereas the objects of the child's world picture could not rightly be claimed to be immutable. The toy is not immutable, it may break or burn. The electric lamp can be smashed to smithereens. This precludes their being called real in the sense just mentioned.

This sounds both self-evident and trivial. But we must bear in mind that in the case of the scientific world picture, where as we have seen, the situation is quite analogous, this state of affairs was by no means found to be self-evident. For just as to the child the toy is the true reality, so for decades and centuries the atoms were taken by science to constitute the true reality in natural processes. The atoms were considered to be that which remains immutable when an object is smashed or burned, thus representing permanency in the midst of all change—until one day, to everybody's astonishment, it was found that even atoms could change. Therefore, whenever in the sequel we refer to the real world, we shall be using the word *real* primarily in a qualified, naive sense, adjusted to the particular character of the dominant world picture, and we must constantly bear in mind that a change in the world picture may go hand in hand, simultaneously, with that which people call real.

Every world picture is characterized by the real elements, of which it is composed. The real world of exact science, the scientific world picture, evolved from the real world of practical life. But even this world picture is not final, but changes all the time, step by step, with every advance of inquiry.

Such a stage of development is represented by that scientific world picture which today we are accustomed to call "classical." Its real elements, and hence its characteristic feature, were the chemical atoms. In our own day, scientific research, fructified by the theory of relativity and the quantum theory, stands at the threshold of a higher stage of development, ready to mould a new world picture for itself. The real elements of this coming world picture are no longer the chemical atoms, but electrons and protons, whose mutual interactions are governed by the velocity of light and by the elementary quantum of action. From today's point of view, therefore, we must regard the realism of the classical world picture as naive. But nobody can tell whether some day in the future the same words will not be used in referring to our modern world picture, too.

III

But what is the meaning of this constant shift in what we call real? It is not utterly unsatisfactory to all men who seek definite scientific insight?

The answer to this question must be, first of all, that our immediate concern is not whether or not the situation is satisfactory, but what its essentials are. But the pursuit of this question will lead to a discovery which we must regard as the greatest of all the wonders previously mentioned. First of all, it must be noted that the continual displacement of one world picture by another is dictated by no human whim or fad, but by an irresistible force. Such a change becomes inevitable whenever scientific inquiry

hits upon a new fact in nature for which the currently accepted world picture cannot account. To cite a concrete example, such a fact is the velocity of light in empty space, and another is the part played by the elementary quantum of action in the regular occurrence of all atomic processes. These two facts, and many more, could not be incorporated in the classical world picture, and consequently, the classical world picture had to yield its place to a new world picture.

This in itself is enough to make one wonder. But the circumstance which calls for ever greater wonderment, because it is not self-evidently a matter of course by any means, is that the new world picture does not wipe out the old one, but permits it to stand in its entirety, and merely adds a special condition for it. This special condition involves a certain limitation, but because of this very fact it simplifies the world picture considerably. In fact, the laws of classical mechanics continue to hold satisfactorily for all the processes in which the velocity of light may be considered to be infinitely great, and the quantum of action to be infinitely small. In this way we are able to link up in a general manner mechanics with electrodynamics, to substitute energy for mass, and moreover, to reduce the building blocks of the universe from the ninety-two different atom types of the classical world picture to two—electrons and protons. Every material body consists of electrons and protons. The combination of a proton and an electron is either a neutron or a hydrogen atom, according as the electron becomes attached to the proton or circles about it. All the physical and chemical properties a body has may be deduced from the type of its structure.

The formerly accepted world picture is thus preserved, except for the fact that now it takes on the aspect of a special section of a still larger, still more comprehensive, and at the same time still more homogeneous picture. This happens in all cases within our experience. As the multitude of the natural phenomena observed in all fields unfolds in an ever richer and more variegated profusion, the scientific world picture, which is derived from them, assumes an always clearer and more definite form. The continuing changes in the world picture do not therefore signify an erratic oscillation in a zigzag line, but a progress, an improvement, a completion. In establishing this fact I have, in my opinion, indicated the basically most important accomplishment that scientific research can claim.

But what is the direction of this progress, and what is its ultimate goal? The direction, evidently, is the constant improvement of the world picture by reducing the real elements contained in it to a higher reality of a less naive character. The goal, on the other hand, is the creation of a world picture, with real elements which no longer require an improvement, and therefore represent the ultimate reality. A demonstrable attainment of this goal will—or can—never be ours. But in order to have at least a name for it, for the time being, we call the ultimate reality the real world, in the absolute, metaphysical sense of the word *real*. This is to be construed as expressing the fact that the real world—in other words, objective nature—stands behind everything explorable. In contrast to it, the scientific world picture gained by experience—the *phenomenological world*—remains always a mere approximation, a more or less well defined model. As there is a material object behind every sensation, so there is a metaphysical reality behind everything that human experience shows to be real. Many philosophers object to the word, *behind*. They say: "Since in exact science all concepts and all measures are reducible to sensations, in the last analysis the meaning of every scientific finding also refers only to the sense world, and it is inadmissible, or at least superfluous, to postulate the existence behind this world of a metaphysical world, totally inaccessible to direct scientific inquiry and examination." The only proper reply to this argument is, simply, that in the above sentence the word behind must not be interpreted in an external or spatial sense. Instead of "behind," we could just as well say, "in" or "within." Metaphysical reality does not stand spatially *behind* what is given in experience, but lies fully *within* it. "Nature is neither core nor shell—she is everything at once." The essential point is that the world of sensation is not the only world which may conceivably exist, but that there is still another world. To be sure, this other world is not directly accessible to us, but its existence is indicated, time and again, with compelling clarity, not only by practical life, but also by the labors of science. For the great marvel of the scientific world picture, becoming progressively more complete and perfect, necessarily impels the investigator to seek its ultimate form. And since one must assume the existence of that which one seeks, the scientist's assumption of the actual existence of a real world, in the absolute sense of the word, eventually grows into a firm conviction which nothing can shake any more. This firm belief in the absolute real in nature is what constitutes for him the given, self-evident premise of his work; it fortifies repeatedly his hope of eventually groping his way still a little nearer to the essence of objective nature, and of thereby gaining further clues to her secrets.

Since the real world, in the absolute sense of the word, is independent of individual personalities, and

in fact of all human intelligence, every discovery made by any individual acquires a completely universal significance. This gives the inquirer, wrestling with his problem in quiet seclusion, the assurance that every discovery will win the unhesitating recognition of all experts throughout the entire world, and in this feeling of the importance of this work lies his happiness. It compensates him fully for many a sacrifice which he must make in his daily life.

The sublime nature of such a goal must, necessarily, dwarf into insignificance any doubt engendered by the difficulties encountered while shaping the scientific world picture. It is particularly important to emphasize this in our own day, for nowadays such difficulties are sometimes regarded as serious impediments to the salutary progress of scientific work. It is an odd fact that experimental difficulties are so regarded to a lesser degree than theoretical ones. The circumstance that with the increasing demands on the accuracy of measurements the instruments, too, become more intricate, is understood and accepted as a matter of course. But the fact that, in the endeavor to improve continually the expansion of systematic interrelations, it is necessary to use definitions and concepts which diverge more and more from traditional forms and intuitive notions, is sometimes cited as a reproach against theoretical research, and is even viewed as indicating that theoretical research is entirely on the wrong track.

Nothing could be more shortsighted than such a view. For if we stop to think that the improvement of the world picture goes hand in hand with an approach to the metaphysically real world, the expectation that the definitions and concepts of the objectively real world picture will not diverge too much from the framework created by the classical world picture amounts basically to a demand that the metaphysically real world be completely intelligible in terms of ideas derived from the former naive world picture. This is a demand that can be never fulfilled. We simply cannot expect to recognize and discern the finer structure of something, so long as we flatly refuse to view it otherwise than with the naked eye. Yet, in this respect there is no reason for fear. The development of the scientific world picture is a matter of absolute necessity. The experiences gained with the refined instruments of measurement demand inexorably that certain firmly rooted intuitive notions be abandoned and replaced by new, more abstract conceptual structures, for which the appropriate intuitions are still to be found and developed. Thus, they are the landmarks to guide theoretical research on its road from the naive concept of reality to the metaphysical real.

But significant as the achievements may be, and near as the desired goal may seem, there always remains a gaping chasm, unbridgeable from the point of view of exact science, between the real world of phenomenology and the real world of metaphysics. This chasm is the source of a constant tension, which can never be balanced, and which is the inexhaustible source of the insatiable thirst for knowledge within the true research scientist. But at the same time, we catch here a glimpse of the boundaries which exact science is unable to cross. May its results be ever so deep and far-reaching, it can never succeed in taking the last step which would take it into the realm of metaphysics. The fact that although we feel inevitably compelled to postulate the existence of a real world, in the absolute sense, we can never fully comprehend its nature, constitutes the irrational element which exact science can never shake off, and the proud name "exact science" must not be permitted to cause anybody to underestimate the significance of this element of irrationality. On the other hand, the very fact that science sets its own limits on the basis of scientific knowledge itself, appears well suited to strengthen everybody's confidence in the reliability of that knowledge, knowledge obtained on the basis of incontestable presupposition and with the help of rigorous experimental and theoretical methods.

If, now, we cast our glance from the viewpoint now established back on the starting point of our considerations, and on the entire train of thoughts pursued, the results gained will become even clearer. We began our deliberations with a definite disillusionment. We sought a universal foundation on which to erect the edifice of exact science, a foundation of indisputable firmness and security—and we failed to find it. Now in the light of the insights gained, we recognize that our quest was doomed to failure even before it started. For, basically considered, our attempt was based on the idea of starting out on our scientific exploration from something irrevocably real, whereas we have now come to understand that such ultimate reality is of a metaphysical character and can never be completely known. This is the intrinsic reason that doomed to failure every previous attempt to erect the edifice of exact science on a universal foundation, valid a priori. We had to be satisfied, instead, with a starting point which was of inviolable solidity and yet of an extremely limited significance, since it was based solely on individual data of experience. It is at this modest point that scientific research enters with its exact methods, and it works its way step by step from the specific to the always more general. To this end, it must set and continually keep its sights on the objective reality which it seeks, and in this

sense exact science can never dispense with reality in the metaphysical sense of the term. But the real world of metaphysics is not the starting point, but the goal of all scientific endeavor, a beacon winking and showing the way from an inaccessibly remote distance.

The assurance that every new discovery, and every new fact of knowledge gained from it, will bring us nearer to the goal, must compensate us for the numerous, and certainly not negligible, drawbacks which are necessarily created by the continual abatement of the intuitive character and ease of application of the world picture. In fact, the present scientific world picture, as against the original naive world picture, shows an odd, almost alien aspect. The immediately experienced sense impressions, the primordial sources of scientific activity, have dropped totally out of the world picture, in which sight, hearing, and touch no longer play a part. A glance into a modern scientific laboratory shows that the functions of these senses have been taken over by a collection of extremely complex, intricate, and specialized apparatus, contrived and constructed for handling problems which can be formulated only with the aid of abstract concepts, mathematical and geometric symbols, and which often are beyond the layman's power of understanding. One might feel completely at sea trying to puzzle out the meaning of exact science, and exact science has even been accused on this account of having lost its firm footing with the loss of its original intuitive character. But he who persists in this opinion, despite the reasons cited, is beyond help, and will be as unable to make any essential contribution to the progress of exact science as an experimenter who insists, as a matter of principle, on working always with primitive instruments only. For exact science demands more than a gift of intuition and willingness to work hard. It demands also very involved, painstaking, tedious attention to details, for which many scientists must often pool their efforts in order to prepare their branch of science for the next step on the ladder of gradual progress. To be sure, when the pioneer in science sends forth the groping feelers of his thoughts, he must have a vivid intuitive imagination, for new ideas are not generated by deduction, but by an artistically creative imagination. Nevertheless, the worth of a new idea is invariably determined, not by the degree of its intuitiveness—which, incidentally, is to a major extent a matter of experience and habit—but by the scope and accuracy of the individual laws to the discovery of which it eventually leads.

Of course, every step forward means also that the difficulty of the task increases, the demands on the analyst grow more exacting, and the need for an expedient division of labor becomes always more urgently imperative. In particular, the division of science into experimental and theoretical was completed about a century ago. Experimenters are the shock troops of science. They perform the decisive experiments, carry out the all-important work of measurement. An experiment is a question which science poses to nature, and a measurement is the recording of nature's answer. But before an experiment can be performed, it must be planned—the question to nature must be formulated before being posed. Before the result of a measurement can be used, it must be interpreted—nature's answer must be understood properly. These two tasks are those of the theorist, who finds himself always more and more dependent on the tools of abstract mathematics. Of course, this does not mean that the experimenter does not also engage in theoretical deliberations. The foremost classical example of a major achievement produced by such a division of labor is the creation of spectrum analysis by the joint efforts of Robert Bunsen, the experimenter, and Gustav Kirchoff, the theorist. Since then, spectrum analysis has been continually developing and bearing ever richer fruit.

Whenever an experimental finding contradicts the accepted theory, another step on the ladder of progress is thereby announced, for the contradiction signifies that the accepted theory must be overhauled and improved. But the question as to just where and how to change it entails serious difficulties. For the more tried an existing theory is, the more sensitive it is, and the stronger resistance it puts up to every attempt to alter it. In this respect, it behaves like a highly complex, widely ramified organism, whose individual component parts are mutually interdependent and are so closely interlinked that a reaction to any stimulus at any one point is also manifested automatically at quite different and, seemingly, very remote places. This gives rise to new questions, which can be investigated experimentally, and thus it may lead to consequences, the bearing and importance of which no one could suspect at the outset. This is how the theory of relativity was born, and this is the story behind the genesis of the quantum theory. In our own days, the constant growth and advancement of the youngest branch of natural science, nuclear physics, brought about and implemented by a reciprocal supplementation of experiment and theory, is another typical example of such fruitful collaboration.

IV

But why all this enormous labor, demanding the best efforts of countless soldiers of science during their entire lives? Is the ultimate result—which, as

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we have seen, in its individual details always drifts away from the immediately given facts of life—truly worth this costly effort?

These questions would indeed be justified if the meaning of exact science were limited to a certain gratification of man's instinctive yearning for knowledge and insight. But its significance goes considerably deeper. The roots of exact science feed in the soil of human life. But its link to it is two-fold. For it not only has its source in experience, but also has a retroactive effect on human life, both material and spiritual, and the more freely it can unfold itself, the stronger and more fruitful is this effect. This manifests itself in a very peculiar manner. First, as we have found, when science works on the world picture of its own making, its quest of metaphysical reality causes it to drift always farther and farther away from the immediate facts and interests of life, since it always takes to less intuitive and more solitary trails. But these trails, and only these, are the very paths leading toward a discernment of new laws of interrelations, which would be inaccessible in any other way, and which can then be made relevant for human experience and thus made to serve human needs.

This fact can be observed in countless individual instances. Here, too, a far-reaching division of labor has proved its worth excellently. The first step, the moulding of the world picture from its beginnings in ordinary experience, is the task of pure science. The second step, the practical utilization of the scientific world picture, is the task of technology. Both these tasks are equally important, and since either of them demands a man's full energy, if an individual scientist wants to make progress in his work, he must concentrate all his energy on one single task and for the time being forget completely other problems and interests. For this reason, never reproach the scholar too harshly for his other-worldliness and his indifference to important problems of human society. Without such a one-sided attitude, Heinrich Hertz could never have discovered radio waves, or Robert Koch the tubercle bacillus. These gifts of pure scientific research to practical life have their counterparts in the manifold stimuli and intelligent assistance which science receives from technology, a fact that is becoming progressively more manifest in our day and whose importance cannot be assessed too highly.

I feel I must discuss here a little more closely, by way of an example, a very recent and very impressive case of the often quite unsuspected close interrelation of science and technology. For a great number of years, only men of pure science were interested in the distinctive facts of atomic transformations. To be sure, the magnitude of the energies thus released did attract attention, yet since atoms were so infinitesimally small, no serious thought was given to the possibility that one day they might acquire practical significance, too. Today, due to new findings in the field of artificial radioactivity, this question has taken an astonishing turn. The investigations of Otto Hahn and his collaborators have established the fact that a uranium atom bombarded by a neutron splits into several parts. Two or three neutrons are liberated, and each of them continues on its own path and may, in its turn, collide with a uranium atom and split it. Thus the effects may multiply; and it may happen that as a consequence of the increasing bombardment of uranium atoms by the liberated neutrons the energy thus released will swell like an avalanche within a very short time. To visualize this, think of the well-known example of chain letters. With the number of available atoms, this chain reaction may reach quite enormous, hardly conceivable proportions. Of course, an indispensable prerequisite for this effect is that the free neutrons, prior to their hitting uranium nuclei, are not captured by other atoms and either permanently absorbed by the latter or deflected away from uranium nuclei.

A specific computation has shown that the amount of energy released in this manner in a cubic meter (35.314 cubic feet) of powdered uranium oxide within one one-hundredth of a second is sufficient to lift a weight of one billion metric tons to a height of almost 17 miles. This amount of energy could replace the output of all the big power plants of the world combined for many years.

Up to quite recently, a technical utilization of the energy latent in the nuclei of atoms might have appeared as a utopian dream. But it was made a reality about 1942, by the impressive collaboration of British and American scientists with American industry, backed by huge government subsidies. At the present moment, several uranium piles are operating in America, and the heat continually produced by them is sufficient to raise the temperature of the Victoria River in the state of Washington by 1 degree Centigrade. So far as the reports disclose, these vast amounts of energy are still unused. Right now, the problem is to get rid of them in a harmless way. But these same piles furnish also the raw materials for the atomic bombs, in which vast amounts of the nuclear energy of the atom are liberated within a fraction of a second, producing explosions beside which the devastation caused by all chemical explosives fades into insignificance. No words can be strong enough to overemphasize the danger of

self-extermination which threatens the entire human race, should a future war bring about the use of a large number of such bombs. Human imagination is incapable of conceiving the possible consequences. A particularly eloquent and forceful plea for peace is the memory of the 80,000 dead of Hiroshima and the 40,000 dead of Nagasaki, a plea addressed to all nations, and especially to their responsible leaders.

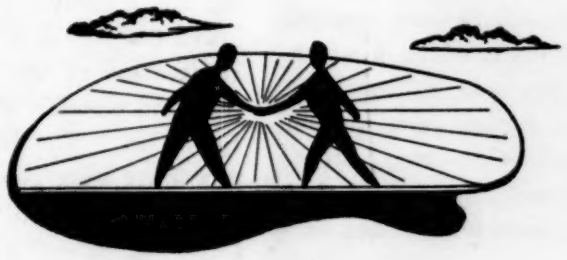
In view of these facts, perhaps many who have lost the art of wondering may feel disposed to learn it anew. And in fact, compared with immeasurably rich, ever young nature, advanced as man may be in scientific knowledge and insight, he must forever remain the wondering child and must constantly be prepared for new surprises.

Thus we see ourselves governed all through life by a higher power, whose nature we shall never be able to define from the viewpoint of exact science. Yet, no one who thinks can ignore it. A thinking human being, who has not only scientific but also metaphysical interests, must choose one of two possible attitudes: either fear and hostile resistance or reverence and trusting devotion. If we reflect on all the unspeakable suffering and incessant destruction of life and property which have plagued mankind since time immemorial, we may be tempted to agree with the pessimistic philosophers who consider life worthless and deny the possibility of permanent progress, of a betterment of mankind, and who profess instead that it is the fate of every human civilization to turn blindly against itself as soon as it reaches a certain peak, and to destroy itself without sense or purpose.

May exact science be cited as an evidence of such a far-reaching view? The answer must be "No," if for no other reason than because science is not qualified to decide the question. From the scientific point of view, one might just as well, and perhaps with even more justification, endorse the opposite opinion. It would require merely an extension of the range of observation, a thinking not in terms of centuries but of many millennia. Or is there anybody who would seriously deny that during the past one hundred thousand years *Homo sapiens* has made progress and has improved himself? Why should this progress not continue further—if not in a straight line, then at least in waves?

Of course, such considerations, such a long range view, are no help to the individual. They cannot bring him succor in his hour of need or cure his pain. The individual has no alternative but to fight bravely in the battle of life, and to bow in silent surrender to the will of a higher power which rules over him. For no man is born with a legal claim to happiness, success, and prosperity in life. We must therefore accept every favorable decision of providence, each single hour of happiness, as an unearned gift, one that imposes an obligation. The only thing that we may claim for our own with absolute assurance, the greatest good that no power in the world can take from us, and one that can give us more permanent happiness than anything else, is integrity of soul, which manifests itself in a conscientious performance of one's duty. And he whom good fortune has permitted to cooperate in the erection of the edifice of exact science will find his satisfaction and inner happiness, with our great German poet, in the knowledge that he has explored the explorable and quietly venerates the inexplorable.

This chapter is taken from the forthcoming book Scientific autobiography and other papers *by the late Max Planck, to be published by the Philosophical Library on October 17.*



TECHNICAL PAPERS

Preparation of Radioautographs of Tissues without Loss of Water-Soluble P^{32}

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A study of techniques for use in preparation of radioautographs with animal tissues which contain radioactive elements in water-soluble form has been made. Conventional histological methods of fixation, cutting, and mounting the tissue result in the loss of a large fraction of the radioactive element before the tissue section is ready for exposure to the photographic emulsion. A recent investigation (*2*) presents evidence which indicates that essentially all of the P^{32} remaining in animal tissues that have been handled by the usual methods is that which has been incorporated in the tissue as newly formed nucleic acids. However, 2 hr after the administration of labeled phosphate to a mature rat the amount of the phosphate that is present as desoxyribosenucleic acid represents only 0.14% in the liver and 4.81% in the intestinal mucosa of the total inorganic phosphorus incorporated in these organs (*1*). The present investigation describes procedures which make it possible to use the radioautographic technique for a more complete study of the distribution of P^{32} in tissues. The objective of the study has been to devise simple methods to prepare the tissue section and mount it on the photographic emulsion without encountering any appreciable loss, or shift in distribution, of the radioactive element.

A recent report by Russel, Sanders, and Bishop (*3*) describes the use of a freezing substitution technique to study the distribution of P^{32} in plant tissues. In this technique the tissue is frozen at $-170°$ C and then transferred to absolute alcohol saturated with basic lead acetate to precipitate the phosphate *in situ* as lead salt during dehydration. While this technique is reported by these investigators to give good results for plant tissues, a somewhat similar technique employed by us with animal tissues has failed to give entirely satisfactory results. Rat tissues were fixed in alcohol-formalin which was saturated with basic lead acetate; this was followed by dehydration with the usual alcohol series, each alcohol solution being saturated with basic lead acetate. Measurements of these solutions for radioactivity showed that very little was lost from the tissue; however, stained sections and radioautographs indicated that the phosphate was being precipitated around the periphery of the tissue, which also hardened and became difficult to cut. Freezing before treatment with a lead salt was not tried.

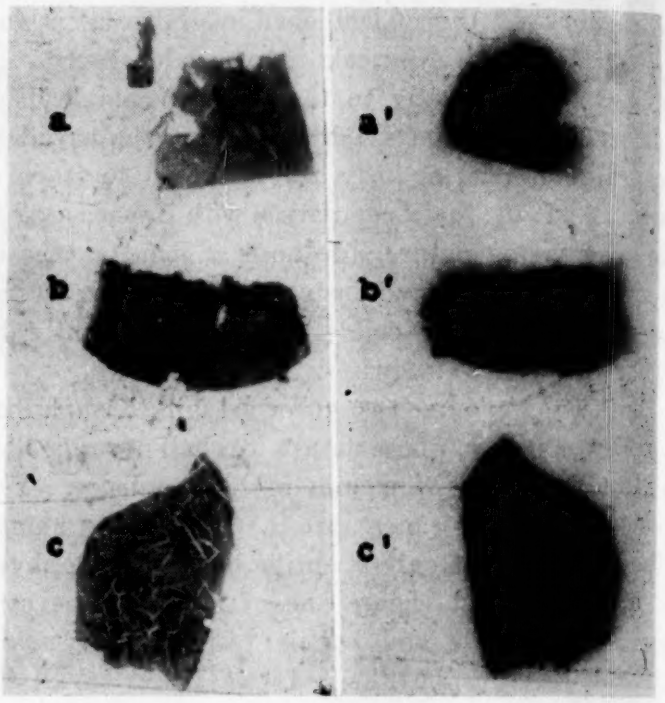

FIG. 1. Stained sections (a, b, c) and corresponding radioautographs (a′, b′, c′) of these sections from three adjacent pieces of the liver of a rat injected with P^{32}; the three sections were fixed and dehydrated by methods A, B, and C respectively as described in the text. (Enlarged approximately 4 ×.)

A freezing and vacuum dehydration technique (method A) for preparing tissues containing P^{32} was tried and the resulting radioautographs have been compared with those obtained from tissues prepared by two other methods.[3] Fig. 1 shows radioautographs and stained sections made from adjacent pieces of the liver of a 96-g rat which had been injected subcutaneously with 0.75 mc of carrier-free P^{32} 2 hr before sacrifice. The section shown in Fig. 1a was prepared by method A, which consists of immersion of the tissue in isopentane cooled to $-170°$ C, followed by vacuum dehydration. Following freezing the tissue was kept at $-70°$ C under a pressure of 0.1 mm Hg for a period of about 48 hr; the tissue was then allowed to come slowly to room temperature in the vacuum. Infiltration of the tissue was accomplished by placing it in liquid paraffin at 40° C under a pressure of 20 mm Hg for 2 hr. The histological results obtained with this precedure were good and were reproducible. The section shown in Fig. 1b was prepared by method B with the following series: alcohol-formalin (9: 1), 2 hr; 95% alcohol, 1 hr; absolute alcohol, 1 hr; absolute alcohol-xylol (1: 1), 1 hr; cedarwood oil, 1 hr; cedarwood oil, over-

[1] Atomic Energy Commission Postdoctoral Research Fellow in the Biological Sciences.

[2] This work was done under contract from the Office of Naval Research and the Atomic Energy Commission. The authors wish to express their appreciation to Mrs. Kathryn Haley for her assistance.

[3] Radioactive phosphorus supplied by the Oak Ridge National Laboratory and obtained on allocation from the U. S. Atomic Energy Commission.

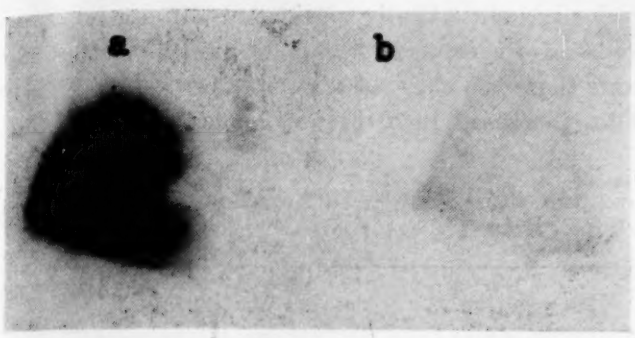

FIG. 2. Radioautographs of two successive sections of rat liver cut from the same block and exposed simultaneously; a differs from b in having no contact with water during the procedure of mounting the tissue on the slide. (Enlarged approximately 4 ×.)

night; clearing in xylol and embedding in paraffin. The series (method C) used for the section shown in Fig. 1c was as follows: alcohol-formalin (9:1), 2 hr; three changes of dioxane (2 hr, 1 hr, 1 hr); followed by the usual paraffin infiltration and embedding. The method of cutting and mounting sections from paraffin blocks was the same with all three sections shown in Fig. 1 and will be described. All three sections were mounted on the same slide and the slide was used for making the radioautographs, which are also shown in Fig. 1 (a′, b′, and c′). The exposure was made by clamping the slide against the emulsion of an Eastman Kodak NTB3 Nuclear Track Plate. The exposure time was 48 hr and was started 14 days after the injection of the animal. This newly developed emulsion is very satisfactory for obtaining radioautographs with P^{32} because of its high sensitivity to high energy beta particles. It can be seen that the amount of P^{32} retained by the tissue, as judged by the radioautographs, is not markedly different in the three methods of fixation and dehydration. However, measurements were made of radioactivity present in the solutions used in preparing tissues by method B and it was found that roughly 25% of the activity present in the tissue was lost to the solutions. This loss was less for method C (i.e., dioxane is preferable to the use of alcohols for dehydration), and in method A (the freezing and vacuum dehydration technique) no loss was possible. These three methods were chosen specifically to minimize the loss of P^{32}. While no data are available, the use of other methods (in particular the use of acid fixatives or prolonged periods of contact with solutions) would probably result in greater loss.

The method of cutting and mounting the sections was found to be very important. It is again desirable to avoid, if possible, contact with all solutions which will extract the P^{32}. This has been accomplished as follows: The sections are cut at the usual thickness of about 8 μ. Before cutting each section, the surface of the block is coated with a thin layer of melted paraffin. After this has cooled for a few seconds the section is cut; allowing the proper cooling time will avoid compression of the paraffin or curling, which occurs if the time is either too short or too long. This layer of paraffin serves as a backing for the section and has avoided the difficulties with curling and folding of the section which occur with a 8-μ section which has no backing and has not been floated on water for flattening. The section may then be mounted directly on a slide and the paraffin removed with xylol or not, as desired. The sections shown in Fig. 1 and in Fig. 2 were cut and mounted in this way on slides coated with a small amount of egg albumen; the slides were placed in the oven (40° C) for a few minutes before removal of the paraffin with xylol. In order to avoid the possibility of chemical action of the tissue on the emulsion, a thin piece of cellophane was placed between the tissue and the emulsion before they were clamped together. Fig. 2 shows radioautographs obtained from two successive sections cut from the same block of frozen, dehydrated liver and exposed simultaneously to the same plate (this was also a 48-hr exposure to an NTB3 emulsion). The two sections were different only in the following respect: after cutting, section 2b was placed on a dish of water with the tissue in contact with the water surface for a period of time judged to be similar to that used in the regular procedure when the ribbon is floated on water before mounting. The marked difference in the density of the radioautographs in Fig. 2a and 2b demonstrates the loss of a large fraction of the P^{32} by floating the section on water.

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On the Relationship of Blood Group A to Rh Immunization and the Occurrence of Hemolytic Disease of the Newborn

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In the course of an analysis of immunological data collected from 11,649 pregnant women during the years 1943–1948 inclusive, there was observed a larger number than expected of individuals of blood group A among the sensitized Rh-negative women who bore infants afflicted with hemolytic disease of the newborn. The question was then raised as to whether a relationship could be established between the presence of group A in the red blood corpuscles and an increased incidence of response to immunization on the part of an Rh-negative woman bearing an Rh-positive fetus; and secondly, whether the presence or absence of hemolytic disease of the newborn could in part be related to the ABO blood group of the Rh-positive infant.

The ABO blood group frequencies of the sensitized Rh-negative women and their offspring were compared with the distribution of ABO blood groups in a random sample of the population of this area. In order to determine

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whether the four ABO blood group frequencies in the category of sensitized Rh-negative women showed statistically significant variations from the normal blood group frequencies, the data were submitted to the chi-square test and the resultant values are listed with the probabilities of their occurrence by chance alone (Table 1). The magnitude of increase of blood group A subjects among sensitized Rh-negative women who bore afflicted infants is one which might be expected to occur by chance alone only twice or thrice in 100 similar samples. It is therefore reasonable to assume that factors other than chance may be responsible for the production of this deviation. The variations in blood group frequencies among sensitized Rh-negative women bearing normal infants (Rh positive or Rh negative) showed no significant variation from the normally occurring distribution of blood groups. These data demonstrate that proportionately more women of blood group A showed Rh sensitization and were delivered of infants suffering from hemolytic disease of the newborn than women of the blood groups O, B, or AB.

Chown (*2*) analyzed the blood groups of 46 mothers of erythroblastotic children and found among them "a significantly greater number of Group AB women and a significantly smaller number of Group B." The frequency of group A in his series was normal. Cappell (*1*) found a significantly higher frequency of group A individuals among sensitized Rh-negative women. Our data differ from those of Cappell in that the significant preponderance of group A subjects occurs among those Rh-negative women who showed laboratory evidence of Rh sensitization and gave birth to infants afflicted with hemolytic disease of the newborn.

When the ABO blood group frequencies in the three categories of infants were compared with the normal frequencies, no statistically significant differences were observed. However, in the sample of Rh-positive normal infants there is a suggestive decrease in group A (29.9%) and an increased incidence of blood group O (53.2%) individuals among them, although the increase is not statistically significant. In the small sample (26) of Rh-negative normal infants, a decrease in group O (23.1%) and an increase in group A (53.8%) occurs. It may be that the sensitized Rh-negative women, who bore the latter group of infants, originally formed Rh antibodies in response to a previous exposure to Rh-positive blood and therefore are to be considered as examples of the "carry-over" or anamnestic phenomena. The data indicate that an Rh-negative blood group A or B fetus *in utero* may stimulate an anamnestic rise of Rh antibodies in an already sensitized woman more readily than a fetus of group O; but this requires further confirmation.

TABLE 1

ABO Blood Group Frequencies in Sensitized Rh-Negative Women and their Offspring Arrayed According to the Clinical Condition of the Child

Categories		Rh positive, hemolytic disease of newborn		Rh positive, normal child		Rh negative, normal child		Totals and average %		ABO blood group in random sample of population
	n =	124		78		26		228		5175
		n	%	n	%	n	%	n	%	
Sensitized Rh-negative women	O	43	34.7	36	46.2	11	42.3	90	39.5	44.8%
	A	66	53.2	32	41.1	10	38.5	108	47.4	39.7%
	B	11	8.9	7	8.9	4	15.4	22	9.6	11.3%
	AB	4	3.2	3	3.8	1	3.8	8	3.5	4.2%
	χ^2 =	9.53		0.46		0.47		5.64		
	p =	0.03–0.02		0.95–0.90		0.95–0.90		0.20–0.10		
	n =*	97		77		26		200		
		n	%	n	%	n	%	n	%	
Children of sensitized Rh-negative women	O	50	51.5	41	53.2	6	23.1	97	48.5	
	A	39	40.3	23	29.9	14	53.8	76	38.0	
	B	7	7.2	12	15.6	4	15.4	23	11.5	
	AB	1	1.0	1	1.3	2	7.7	4	2.0	
	χ^2 =	4.72		5.87		5.19		3.07		
	p =	0.20–0.10		0.20–0.10		0.20–0.10		0.50–0.30		

* The differences in numbers of sensitized Rh-negative women and children born to them are due to lack of information concerning the ABO groups of 28 infants.

In summary, in a sample of 228 sensitized Rh-negative women, 124 bore children afflicted with hemolytic disease of the newborn. Of these 124 women 66 (or 53.2%) belonged to blood group A. The chi-square test on these data demonstrate that they are of probable statistical significance ($p = 0.03$–0.02) and the inference may be made that this unusual increase in the incidence of blood group A mothers is not due to chance alone. These data indicate a possible relationship between blood group A of the mother and the character of her immune response to the Rh factor as antigen. The infants afflicted with hemolytic disease of the newborn showed a normal distribution of ABO blood groups.

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rontianite and Witherite Associated with outhern Illinois Fluorite

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Strontianite and witherite have been identified in specimens of fluorspar from the Minerva Oil Company Mine . 1, NW¼ SE¼ sec. 24, T. 11 S., R. 9 E., about 5 miles rth of Cave-in-Rock, Hardin County, Illinois. The iginal specimens were collected on October 25, 1948, by arles E. Tothill, on a senior student trip through the ne. These specimens consisted of barrel-shaped mosaic gregates which had been identified as barite. The student, impressed by the unusual habit of the "barite," ought the specimens to the senior author, who recogzed the crystals as witherite twins. Upon request, the perintendent of the mine, Mr. Gill Montgomery, furshed additional specimens of the same material. At e suggestion of the senior author, the junior author sited the mine during the Christmas vacation to study e occurrence of the minerals. The complete results of s study will be published later.

The fluorite in the Minerva Oil Company Mine No. 1 places the Downey's Bluff (Renault) limestone of Upr Mississippian, Chester age. The deposit is capped by e Bethel sandstone of the same age. Similar replaceents in other Chester and Ste. Genevieve limestones are und at Cave-in-Rock at Crystal, Davis No. 2, Lead ll, Victory, and other mines east of the Peters Creek ult zone in southern Illinois. In answer to a query ncerning the occurrence of witherite in the Cave-in-ck district, E. A. Brecke stated that early in 1943 he d noted the pseudohexagonal twins in the West Green ine of the Ozark-Mahoning Company and had identified em as witherite. In this mine, according to Brecke, e fluorite replaces the Fredonia limestone and the posit is capped by the overlying Rosiclare sandstone.

The principal commercial mineral in the Cave-in-Rock strict is fluorite, but it is accompanied by barite, calcite, alcopyrite, galena, greenockite, quartz, sphalerite, strontianite, and witherite. Although galena is recovered at e Ozark-Mahoning mill, only the cadmium-bearing sphalite and the fluorite are recovered at the Minerva Oil mpany Mine No. 1. According to Mr. Montgomery, a dden increase in the barium content of the fluorspar ncentrate was noted as soon as fluorspar from a new ope began to be milled. In this stope the so-called "hexgonal barite crystals" were found. The flotation reaents that previously had been successful in depressing e barite were not effective on this unusual form of "barite," which floated and was concentrated with the fluorite. fter the barium mineral was correctly identified as witherite, the high barium content of the fluorspar concentrate om the new stope was explained. Examination of the mine showed that witherite is present in minor amount throughout the mine, but in the new stope it occurs in larger crystal aggregates and it is more abundant than elsewhere. Since the discovery of the witherite, adjustment of the mill feed has made possible the maintenance of a flotation product that is acceptable to the glass industry.

The witherite occurs in pseudohexagonal twinned mosaic crystals with dense, creamy-white, waxy-lustered cores which are surrounded by nearly colorless, twinned, glassy crystals. The twins have a maximum length of 3 in. and a width of 1½ in. The dominant forms are the unit prism and several dipyramids. The crystals appear to be terminated by basal pinacoid faces but closer examination reveals that the terminal faces belong to a poorly developed, nearly flat dipyramid. The pseudohexagonal form of the twins is usual for witherite twinned on the unit prism, but the twins from the Minerva mine are unusual in exhibiting not only the usual cyclic twinning but also polysynthetic twinning, as well as mosaic structure. These features are revealed in thin sections examined in polarized light. The twins are not as simple as they appear. Under an ultraviolet lamp the witherite exhibits a strong whitish fluorescence and a weak phosphorescence. Identification of the mineral was verified by qualitative chemical tests, accurate density determinations, and by an X-ray diffraction pattern. Vugs in the deposit are lined with witherite, which appears to be an alteration product of barite, although not always is it directly associated with barite. The barite does show the effects of solution and much of it occurs in dull white pulverulent masses. In the Ozarks-Mahoning Mine the witherite is corroded. Here it is closer to the surface than at the Minerva Oil Company's mine and it has been partially dissolved by circulating ground water.

The strontianite occurs in slightly pinkish bladed grains and in brown fibrous aggregates. The brown coloration is due to a slight amount of oil associated with the mineral. Both forms of strontianite are distinctly radial. Crystals of this mineral have not been observed. Identification was based on chemical tests and upon X-ray diffraction patterns. Strontium has not hitherto been reported as occurring in this deposit. Strontianite was deposited prior to the barium-bearing minerals and after the sphalerite and the bulk of the fluorite.

A preliminary study indicates that the order of crystallization of the minerals at the Minerva Oil Company Mine No. 1 is: fluorite, sphalerite, calcite, barite, strontianite, witherite, fluoride, quartz, and calcite, with chalcopyrite being deposited contemporaneously with witherite and with both the early and the late fluorite. Although a little galena does occur at this property its exact mineral relationships could not be determined from the specimens collected by the writers. Additional studies are being made to work out the paragenesis in greater detail. The search for witherite and strontianite has been extended to other mines in the Cave-in-Rock district and to the vein deposits at Rosiclare, but to date additional occurrences have not been found.

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Grignard Coupling at High Temperatures

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The reaction $2RX + Mg \rightarrow MgX_2 + R\text{-}R$, in ether solution, occurs readily when R is an allylic group (*1*), to a small extent when R is alkyl (*1*), and apparently not at all when R is vinyl or a substituted vinyl group (*2*).

A method has been used which increases the yield of such reactions. The pure halide vapor is passed through a tube of magnesium turnings at temperatures over 250° C, in a helium atmosphere. Yields of 10% of octane are obtainable from one pass of *n*-butyl bromide at 330° C, at a rate of 3 ml/min through a tube of magnesium 18 mm in diam and 80 cm long. Unused halide may be recovered by distillation. The magnesium bromide (or chloride) forms a porous film on the magnesium and does not prevent it from reacting until it is substantially consumed.

When a vinyl halide (1-chloro-2-methyl-1-propene) was passed over magnesium in helium at 340° C, and the product distilled, a drift in physical properties at the end of the distillation indicated the presence of small amounts of octenes, but no identified product other than the starting material was isolated.

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The Preparation of Formaldehyde-C^{14}[1]

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No satisfactory preparative method for formaldehyde-C^{14} has been reported. The production of this important intermediate has now been accomplished by an adaptation of the formaldehyde synthesis of Henry (*1*) and of Michael (*2*). Vacuum line technique was used.

Methyl-C^{14} acetate was prepared by reaction of methanol-C^{14} (*3*) with acetyl chloride. The monochlorination of methyl acetate to produce chloromethyl acetate, indicated by Henry to be favored by moderate temperatures, was performed in the present case by allowing a frozen equimolar mixture of chlorine and methyl-C^{14} acetate to warm to room temperature. The product, chloromethyl-C^{14} acetate, a methylenating agent (*5*), was readily hydrolyzed with excess water to produce a formalin solution of any desired concentration containing acetic and hydrochloric acids. Vacuum distillation of this solution gave para-formaldehyde as a residue and a more dilute formaldehyde solution as the distillate.

[1] This document is based on work performed under Contract Number W-7405 eng 26 for the Atomic Energy Project at Oak Ridge National Laboratory.

The yield of formaldehyde solution from methanol was consistently about 60%, analyzed by precipitation of the dimedone derivative. The specific activity of formaldehyde-C^{14}-dimedone prepared by this procedure from methanol-C^{14} (12.00 μc/millimole) was 12.18 μc/millimole as determined by dry combustion and ion-current measurement by means of a vibrating reed electrometer (*4*).

Thirty millicuries of neutral formaldehyde solution of specific gravity 250 μc/millimole have been prepared by dilution of the hydrolysis solution with carrier formalin, neutralization, and distillation at atmospheric pressure.

Studies are in progress involving the chlorination of the methyl esters of other acids and use of formaldehyde-C^{14} and chloromethyl-C^{14} acetate as synthetic intermediates.

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Determination of the Fate of Calcium in the Laying Hen by Means of Radiocalcium (Ca^{45})[1]

J. W. T. Spinks, M. R. Berlie, and J. B. O'Neil[2]

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Calcium metabolism in the laying hen can be studied with the aid of Ca^{45}. A direct approach to this problem is to replace the limestone powder in the mash by $CaCO_3$ containing Ca^{45} (*1*). In a typical experiment a hen ("A") was fed 1.71 g $CaCO_3$ with a Ca^{45} activity of approximately 2×10^6 cpm. The calcium in the eggs and droppings was separated in the usual way as CaC_2O_4 and its activity determined by means of a thin window Geiger counter. Corrections for decay and self-absorption were made. Total calcium was determined. The percentages of Ca^{45}, which are also the percentages of active $CaCO_3$ appearing in different parts of successive eggs are shown in Fig. 1.

The close similarity of this curve with that reported by Comar and Driggers (*2*), who administered 1 mg of radioactive calcium as a solution of the chloride to the lower esophagus of a fasted bird, is worthy of note. The recovery of calcium was at a maximum (29%) in the shell of the second egg and decreased very rapidly in the shells of later eggs. This is in agreement with the well known fact that the shell is laid down in about 20 hr of oviposition. Fig. 2 shows the percent uptake of Ca^{45} in the shell, white, and yolk. The histogram for the yolk

[1] Paper given at a meeting of the Chemical Institute of Canada at Saskatoon on October 9, 1948.

[2] We are indebted to the National Research Council of Canada for financial assistance.

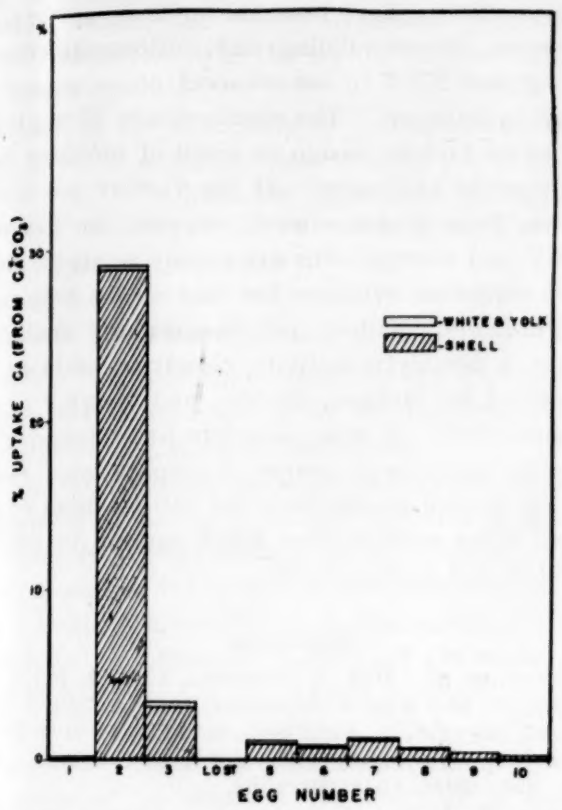

FIG. 1. Percentage of Ca^{45}, fed as a single dose of radioactive $CaCO_3$, appearing in successive eggs.

of interest, since it is in marked contrast to those for the white and the shell but is in good agreement with that previously reported for phosphorus uptake (*3*). A large portion (50%) of the calcium was excreted within 48 hr. Another bird ("B") was then given a daily feed containing 1.7 g of active $CaCO_3$ for 10 consecutive days (multiple feeding trial). The results of this trial (Fig.) indicate that the percentage uptake of calcium from a given source (in this case active $CaCO_3$) became relatively constant in about 8 days after the first feeding.

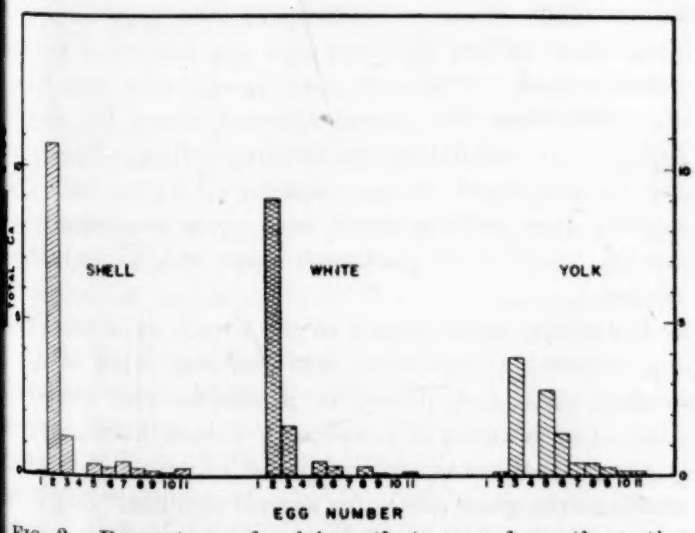

FIG. 2. Percentage of calcium that came from the active $CaCO_3$, appearing in shell, white, and yolk of successive eggs.

This is in striking contrast to the 15 days for P^{32} (*3*) but is still in excellent agreement with theory. Since the calcium fed in a given day appears in a number of eggs, it follows that the calcium in any given egg comes from the calcium fed on many different days. Thus, the recovery of calcium (expressed as a percentage of the daily calcium fed) in successive eggs in a multiple feeding experiment is a summation of the recoveries in successive single feeding experiments (see Fig. 3, hen "A").

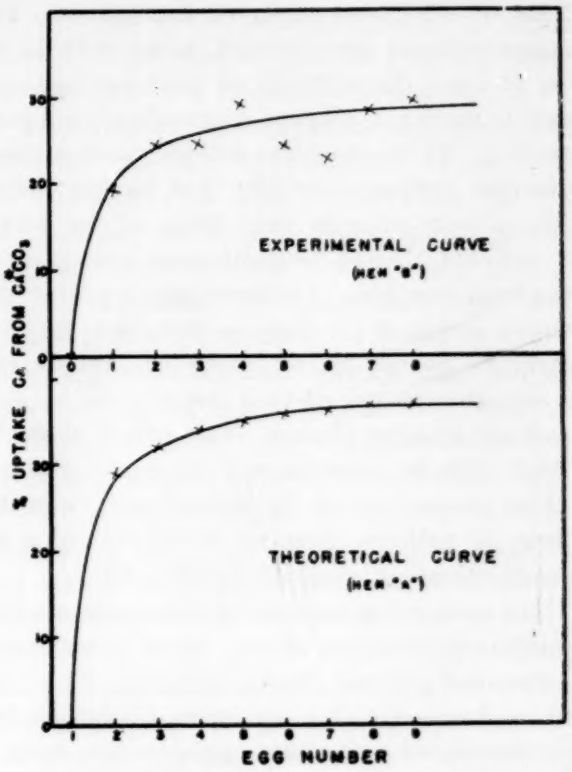

FIG. 3. Percentage of daily feed of calcium appearing in successive eggs in multiple feeding trial; theoretical curve (hen "A"), experimental curve (hen "B").

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Serologic Relationships of Mumps and Newcastle Disease

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Department of Animal Diseases,
***University of Connecticut, Storrs,* and**
Department of Epidemiology,
Harvard School of Public Health, Boston

The presence of neutralizing and antihemagglutinating factors against Newcastle disease virus (NDV) in half of patients convalescing from mumps suggests a possible relationship between the two viral agents. These cross-reacting factors were first observed in the course of an outbreak of mild meningo-encephalitis, suggestive of Newcastle disease because the epidemiologic and clinical findings fitted descriptions by Howitt *et al.* (*4*) of a disease in man which led to the formation of NDV neutralizing antibodies. Paired sera from cases of mild meningo-encephalitis showed little or no rise of neutralizing capacity against NDV, but a few pairs of mumps sera included as controls exhibited a sharp rise against this virus. Accordingly mumps sera were further investigated. Neutralization tests and calculation of neutralization indices were made by methods similar to those described by Howitt *et al.* (*4*), with few modifications. The California strain

No. 11,914 of NDV was employed throughout. Twenty-two mumps patients were studied, along with 23 control patients, 17 from the outbreak of mild meningo-encephalitis, and 6 having a clinical diagnosis of nonparalytic poliomyelitis. Thirteen of the mumps patients developed neutralization indices over 250, ten having indices of 1,000 and above, whereas only three of the sera from control patients showed neutralization indices over 250 and none went over 800. Antihemagglutination tests with mumps sera against NDV likewise demonstrated serologic relationships. Seven of 20 pairs of heat-inactivated mumps sera showed 4-to-64-fold rise of titer between the acute and convalescent phases. Four others showed titers of 1:64–1:256 in convalescent phase sera, titers well above those encountered in 20 pairs of sera from the control group of patients, none of which showed a rise of antihemagglutinating capacity against NDV.

The diagnosis of mumps in the patients studied has been considered elsewhere (*6*, *9*). In addition to confirmatory epidemiologic and clinical findings, all of the patients showed evidence of recent mumps infection by complement fixation or by antihemagglutination tests, using the Enders strain of mumps virus. Mumps virus was isolated from the saliva or spinal fluid of 11 patients.

The positive results obtained in two types of serological tests against NDV in the sera of patients experiencing infection with mumps virus suggests that a diagnosis of Newcastle disease in humans should be made with caution, especially in the absence of virus isolation. Only five cases of human infection with NDV (*1*, *2*, *5*), all having mild conjunctivitis, have been known to be so confirmed. The presence of neutralizing and antihemagglutinating factors against NDV in convalescent phase mumps sera is difficult to interpret. The reactions may be due to non-specific serum factors arising as result of infection rather than to specific antibodies. If the factors are actually antibodies, their presence would support the hypothesis that NDV and mumps virus are closely related. Burnet (*3*) first presented evidence for this in his work on receptor gradients. Kilham (*7*) has recently shown that NDV has a hemolytic activity closely resembling that demonstrated by Morgan, Enders, and Wagley (*8*) for the mumps virus. A more complete presentation of the data in this paper is in course of preparation. Further studies are needed to elucidate the full meaning of serologic and other relationships which appear to exist between NDV and mumps virus.

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Comments and Communications

Method for Isolation of *Actinomyces israeli* from Dento-Bacterial Plaque[1]

The dento-bacterial plaque is a minute mass of salivary debris and bacterial cells firmly attached to inaccessible tooth surfaces. The association of the plaque with the initial lesion of dental caries has been firmly established (Dietz, F. H. *J. D. Res.*, 1943, **22**, 423; Stephan, R. M. *J.A.D.A.*, 1940, **27**, 218). A microsectional study (Ennever, J., Robinson, H. B. G., and Kitchin, P. C. *J. D. Res.*, 1948, **27**, 599) of the bacterial plaque has shown that bizarre, elongated, apparently branched, Gram-positive rods make up a large portion of the plaque stroma. As a result of this morphologic suggestion, a study was undertaken to determine whether *Actinomyces israeli* is a consistent component of the plaque flora.

After repeated trials it became apparent that uniform recovery of *A. israeli* from plaque material was not possible by the method of Rosebury, Epps, and Clark (*J. Inf. Dis.*, 1944, **34**, 131), even though their method affords an excellent means of cultivating the organisms from gingival scrapings, actinomycotic pus and other contaminated sources. It was felt that the sporadic isolations of *A. israeli* from the plaque centered about the physical difficulty of inoculating the culture medium. The following modifications of the Rosebury, Epps, and Clark method were instituted and have given consistently successful isolation of *A. israeli* from the dento-bacterial plaque.

The plaque mass, grown in the mouth on a tooth-bearing removable appliance, was removed with a sterile hooked blade and placed in a micromortar containing 0.05 ml of autoclaved saline with Triton A-20 at 1:200. A coarse suspension was prepared by trituration with a small, sterile glass pestle for several minutes. One visible granule was transferred by means of a capillary pipette to brain-heart infusion agar, streaked, and the preparation incubated anaerobically in an atmosphere of 5% CO_2 for six days.

Fifteen attempts to isolate *A. israeli* from this source have been uniformly successful. Care, however, must be exercised in seeding the visible granule. It is imperative that only a small quantity of the saline diluent accompany the granule. If too much liquid is introduced on the

[1] This study from the Ohio State University, College of Dentistry, and Research Foundation, Columbus, Ohio, was supported by a grant from the Proctor and Gamble Company, Cincinnati, Ohio.

culture medium, the easily emulsified portions of the plaque flora, present in the liquid, outgrow and obscure the *A. israeli*.

Studies of the occurrence of *Actinomyces israeli* in a large series of dento-bacterial plaques are in progress.

J. ENNEVER, HAMILTON B. G. ROBINSON, and PAUL C. KITCHIN

The Ohio State University

Statement on Visa Action

Seventy-nine scientists attending the Fourteenth Cold Spring Harbor Symposium on Quantitative Biology in June signed the following statement:

"We, the undersigned scientists, in attendance at a Symposium on Amino Acids and Proteins at the Biological Laboratory, Cold Spring Harbor, June 8 to 16, 1949, desire to protest the action of the United States authorities in refusing a visa to our British colleague, Dr. R. L. M. Synge. A presumptive political affiliation has been given as a reason for the refusal to allow Dr. Synge to attend this scientific conference, which has no political implications. This regrettable action has deprived the Symposium of the scientific judgment of an exceedingly able worker, and thus has done disservice to the progress of science in this country. Furthermore, we sincerely believe that it is in the national interest to permit scientists such as Dr. Synge to visit the United States.

Resolved, That this statement be sent to the President of the United States, and copies to the Secretary of State, the Attorney General, the Chairmen of the House and Senate Committees on Foreign Relations, the President of the National Academy of Sciences, the National Research Council, and *Science*."

Scientists attending the symposium were shocked by the refusal of the Department of State to grant a visa to Dr. Synge, since he is not a communist, but a man of liberal views and not active in politics. They were also disturbed by the discourteous treatment shown this prominent British colleague by American officials. Dr. Synge applied for a visa in March, at the American consulate in Edinburgh; and even though he was assured that a prompt answer to his application would be forthcoming, he never received an official notification of the decision to refuse it. After repeated requests for a decision, the director of the Biological Laboratory was informed by the Visa Division of the Department of State of the refusal to grant a visa only seven days before the beginning of the symposium.

M. DEMEREC

Long Island Biological Association

NEWS and Notes

Max S. Dunn, professor of chemistry at the University of California at Los Angeles, has been named faculty research lecturer for 1949–50. Dr. Dunn was selected in recognition of his contribution to the development and application of microbiological methods for the quantitative estimation of amino acids.

L. G. M. Baas Becking, deputy chairman of the South Pacific Commission Research Council, has been named chairman of the Committee on Botanical Stations of the International Union of Biological Sciences.

Gordon Ferrie Hull, Jr., professor of physics at Dartmouth College, has received a leave of absence to study European developments in physics for the Office of Naval Research. Dr. Hull will also deliver lectures on research which he has been conducting at Dartmouth. He will have his headquarters at the U. S. Embassy in London.

Louis N. Katz, director of cardiovascular research at the Michael Reese Hospital, Chicago, will deliver the 12th Annual Louis Gross Memorial Lecture, October 26 at the Jewish General Hospital in Montreal, Canada. Dr. Katz' subject will be "Clinical Electrocardiography — Its Present Position and Possible Potentialities."

David G. Mandelbaum, professor of anthropology at the University of California, has begun a series of studies of the Kotas, inhabitants of the Nilgiri hills of South India. Dr. Mandelbaum will visit Delhi, Bombay, Madras, and Calcutta. His work will be made possible by a Guggenheim fellowship and grants from the Social Science Research Council and the university's Rockefeller Committee on Far Eastern Studies.

Gordon R. Willey, acting director of the Institute of Social Anthropology of the Smithsonian Institution, has been appointed Bowditch Professor of Central American and Mexican Archaeology and Ethnology of the Peabody Museum, Harvard University, effective July 1, 1950. Professor Willey is the first holder of the Bowditch professorship.

Richard W. Cook, who has been acting manager of the Atomic Energy Commission's operations at Oak Ridge, has been appointed manager. Mr. Cook succeeds **J. C. Franklin,** who resigned in June.

John L. Brooks, assistant professor of zoology at Yale University, has just returned from Burma. While serving as visiting professor of zoology at Rangoon University during the academic year 1948–49, Dr. Brooks organized a research program in freshwater biology.

Lynn S. Beedle, research engineer for the Department of Civil Engineering at Lehigh University, will spend three months at Cambridge University coordinating liaison on studies being made at the two universities on the strength of welded steel frames and their components. The trip is sponsored by the Welding Research Council and the Office of Naval Research, in cooperation with the American Institute of Steel Construction, the American Iron and Steel Institute, and the Lehigh University Institute of Research.

UNIVERSITY OF MICHIGAN LIBRARIES

Visitors to U. S.

Sir John L. Simonsen, British chemist, and director of Great Britain's Colonial Products Research Council, arrived in New York City September 16. Sir John addressed the American Chemical Society's Division of Organic Chemistry at the Atlantic City meeting and received the new $1,000 Fritzsche award for his research in essential oils.

Etienne Wolff, professor of zoology and experimental embryology at the University of Strasbourg, France, is spending several months visiting the laboratories of experimental embryology at a number of colleges and universities, including Yale, Connecticut, Chicago, Amherst, Johns Hopkins, and Washington University at St. Louis.

Visitors at the National Bureau of Standards during the week of September 12 included **Olli Ant-Wuorinen,** director, Chemical Laboratory, State Institute for Technical Research, Helsingfors; **S. S. Bhatnager,** director, Indian Scientific Research Office, New Delhi; **W. P. Fletcher,** British Rubber Producers' Association, England; **L. C. Jackson,** Department of Physics, University of Bristol, England; **Halvor Nordbo,** of the Agricultural College of Norway; **Hugh C. Simpson** and **Hugh Thompson,** both of the Imperial Chemical Industries Ltd., England.

Grants and Awards

The Oak Ridge Institute of Nuclear Studies has granted research awards to Alfred Brauer, professor of mathematics at the University of North Carolina, Walter Gordy, associate professor of physics at Duke University, and Allen T. Gwathmey, associate professor of chemistry at the University of Virginia. The awards were presented for "significant contributions to science in the South."

The Society for Pediatric Research has announced that during the academic year 1948–49, seven Mead Johnson Fellows were appointed and have completed a year's postgraduate work. The seven fellows and the institutions at which they have worked are: *Fabio do Amaral,* Brazil, Children's Orthopedic Hospital, Seattle, Washington; *Hsu Hankuang,* China, Children's Hospital, University of Cincinnati, and the Phipps Institute, University of Pennsylvania; *Soledad Manalac-Morales,* Philippines, Pediatric Department of the Bellevue Hospital, New York University; *M. Vera Buhrman,* South Africa, Rochester Child Health Project, Mayo Clinic; *Alfonso Cardenas,* Colombia, Children's Hospital, and Department of Pediatrics, University of Louisville, Kentucky; *Eugenia Rosemberg,* Argentina, Harriet Lane Home, Johns Hopkins Hospital; and *Jamil Kheder,* Iraq, Children's Hospital, Columbus, Ohio.

The John Scott Award, established in 1816 "for ingenious men and women who made useful inventions," was presented this year to Frank W. Caldwell, director of research at the United Aircraft Corporation of East Hartford, Connecticut. Mr. Caldwell received the award for his work in developing the controllable pitch propeller.

Fellowships

The Marine Biological Laboratory, Woods Hole, Massachusetts, through a grant from the Lalor Foundation, is offering a limited number of postdoctoral fellowships in the fields of biochemistry, biophysics, and physiological chemistry. The fellowships are designed primarily for young scientists desiring to work during the summer on investigations for which the opportunities provided by the laboratory are particularly appropriate. The stipend is intended to cover laboratory fees, travel, and living expenses at Woods Hole. Applications should be received by *December 31.* Blanks and further information may be secured from the director of the Marine Biological Laboratory.

The National Heart Institute of the U. S. Public Health Service has inaugurated a research training program in enzyme chemistry with particular reference to heart muscle at the Institute for Enzyme Research of the University of Wisconsin. David E. Green, professor of enzyme chemistry, is the program director. Candidates must possess a Ph.D. or M.D. degree in order to qualify. Stipends for research trainees conform to those in effect for postdoctorate research fellows of the Public Health Service. The training program will include full-time research in some phase of enzyme chemistry and a regular series of lectures by members of both the institute's staff and other departments of the university of Wisconsin, and by guest lecturers from other universities. A trainee can start the program anytime between October 1949 and October 1950. The period of traineeship is 12 months; the number is limited to 10 each year and may include senior investigators. Application forms may be obtained from the Institute for Enzyme Research, Madison, Wisconsin. Completed applications should be submitted in duplicate to Dr. Green.

Stanford University has announced the establishment of a fund to provide five fellowships in aeronautical engineering. Known as the **Milton Reynolds-Bill Odom Fellowship Fund,** it was begun by Milton Reynolds, manufacturer of electronic equipment, and has received a supplementary gift from the Chicago section of the American Society of Mechanical Engineers.

Meetings and Elections

The 15th Conference of the International Union of Chemistry was held at Amsterdam September 6–10 under the presidency of N. R. Kruyt. Raymond Delaby, of Paris, is the general secretary of the union.

Nearly 300 persons were in attendance, representing most of the thirty countries adhering to the union. Russia, although adhering to the union and represented at the London Conference in 1947, did not send delegates. Representation from countries under Russian influence was limited, but not entirely lacking. The U. S. representatives numbered 16: W. Albert Noyes, Jr., vice president of the union, Roger Adams, E. Bartow, Ralph Conner, Warren C. Johnson, I. M. Kolthoff, J. Murray Luck, H. F. Mark, H. Nutting, Emil Ott, Austin M. Patterson, J. W.

Perry, A. Silverman, E. R. Smith, Edward Wichers, and J. H. Yoe.

The principal administrative body of the union is a council, on which each adhering country is represented by two, four, or six delegates, the number being fixed by the extent of scientific activity in the country, rather than by its size. Thus Switzerland has six delegates, as have France, Great Britain, Russia, Sweden, and the U. S.

The work of the union is done by 20-odd commissions. Membership in these commissions is determined primarily by individual interest and scientific competence, rather than by geographical considerations. These commissions deal mainly with matters of international standardization in such things as nomenclature, symbols and terminology, atomic weights, and physicochemical constants. Certain commissions promote the standardization of procedures, both for measurements of constants and for chemical analysis, and there is an important commission on documentation. The last named commission held numerous sessions during the week in an effort to assist in maintaining the *Beilstein encyclopedia of organic substances* and the *Gmelin handbook of inorganic chemistry*. Both of these, of course, were crippled by the collapse of Germany. It is gratifying to report that *Beilstein* has a very good prospect of recovery, but the reluctant decision with respect to *Gmelin* was that the annual support of $100,000 estimated as required to continue the present plan of operation simply could not be provided and that a complete editorial reorganization was needed if this important work was not to fail.

Other commissions worked equally seriously, although with less time needed to complete their agenda. Altogether, probably fifty or sixty technical sessions were held, with results that indicate that the union, as reorganized after the war, has a good prospect of worthwhile accomplishment in promoting the science of chemistry, not only by eliminating sources of misunderstanding and confusion, but by positive actions of international agreement. In such a field as nomenclature, for example, the importance of the work at Amsterdam can hardly be overestimated.

The council voted to resume an earlier name, "International Union of Pure and Applied Chemistry," with the object of advertising its interest in technology, as well as pure chemistry. It also made plans for a sectional organization under such general headings as analytical, inorganic, organic, biological, physical, and applied chemistry. These plans are provisional, pending further study during the interval before the next general conference, which is to be held in New York and Washington in September, 1951. At that time the union will also sponsor an International Congress of Pure and Applied Chemistry, which is expected to attract an attendance of some thousands, by reason of the programs of scientific papers which will be presented.

The excellent reputation of the Dutch as hosts for international gatherings was fully upheld. A delightful program of entertainment was provided, including a reception by the government in the Rijksmuseum and a concert by the renowned Concertgebauw Orchestra. Arrangements for the reception of visitors and for the technical sessions, as well as for official entertainment, were flawless.

EDWARD WICHERS

AAAS Subsection Nd—Dentistry, will hold three sessions of papers dealing with research on growth and development of the face, jaws, and teeth from the anatomical, anthropological, biochemical, and physiological viewpoints, at the Hotel McAlpin, Friday morning, afternoon, and evening, December 30. All inquiries should be addressed to Frances Krasnow, 422 East 72nd Street, New York City 21.

The Plant Science Seminar, at its recent meeting at the University of Wisconsin, elected the following officers to serve for the year 1949–50: chairman, Elmer L. Hammond, University of Mississippi; first vice chairman, Heber W. Youngken, Jr., University of Washington; second vice chairman, Paul D. Carpenter, University of Illinois; secretary, Edward P. Claus, University of Pittsburgh. J. Allen Reese, University of Kansas, and J. Hampton Hoch, Medical College of South Carolina were elected to the executive committee.

The U. S. Pharmacopoeial Convention elected Lloyd C. Miller, director of the Biology Division of the Sterling-Winthrop Research Institute, Rensselaer, New York, as director of pharmacopoeial revision for the new decade. Dr. Miller will succeed E. Fullerton Cook, who has been chairman since 1920.

Deaths

William J. Rooney, 57, of the Department of Terrestrial Magnetism, Carnegie Institution of Washington, died August 31 at Tooele, Utah, from injuries incurred in an automobile accident. He had been conducting special seismic investigations in California for the past two months. Mr. Rooney was considered an authority on earth currents and resistivity and had conducted research work in Australia, Guatemala, Peru, Spain, and the U. S. in this field.

Lawrence Edmonds Griffin, 75, retired professor of marine biology at Reed College, died September 12. Dr. Griffin was an authority on the dogfish shark.

August Krogh, 75, physiologist, died at his home in Copenhagen on September 13. Dr. Krogh was best known for his investigations of the capillaries. He received the Nobel Prize in physiology and medicine in 1920.

William Sargent Ladd, 62, former dean of the Cornell University Medical College, died of a heart attack on September 17. Dr. Ladd was an attending physician to the New York Hospital, a consultant to the Department of Medicine of the Nassau Hospital Association, and a trustee of the Memorial Hospital and the New York Academy of Medicine.

Durwald F. Fisher, 61, horticulturist at the Department of Agriculture, Bureau of Plant Industries, Beltsville, Maryland, died September 18 of a heart attack. Mr. Fisher conducted extensive research in the handling, transportation, and storage of fresh fruits and vegetables.

Prize winners in the **Third International Photography-in-Science Salon,** the annual competition for scientists and photographers, sponsored by *The Scientific Monthly,* were announced September 25. Judges were Merle A. Tuve, of the Carnegie Institution, for physical sciences; Walter F. Jeffers, of the Department of Botany, University of Maryland, for the biological sciences; A. A. Teeter, of Charles Pfizer and Company, New York City, for chemistry; Emanuel Krimsky, of Polyclinic Hospital, New York City, for the medical sciences; and Alexander J. Wedderburn, of the Graphic Arts Division, Smithsonian Institution, for photography.

The prints will be on exhibition at the U. S. National Museum, Washington, D. C., October 3–31, and at the Annual Meeting of the AAAS, New York City, December 26–31. The exhibit will then go on tour of important scientific institutions in this country and abroad.

Prize winners in the black-and-white division were: *First:* L. L. Marton, chief, Electron Physics Section, National Bureau of Standards, Washington, D. C., for "Electron-optical shadow method, a new technique making it possible to photograph and study quantitatively electrostatic and magnetic fields of extremely small dimensions." *Second:* Bernard Henry Mollberg, University of Houston, Texas, for "Ventrosinistral view of dried chick embryo which has been plated with aluminum, revealing obscure details of surface anatomy." *Third:* S. B. Newman, Emil Borysko, and Max Swerdlow, National Bureau of Standards, Washington, D. C., for "Electron micrograph of thin section of cells in onion root tip." *Honorable mention:* Jose Oiticica, Rio de Janeiro (Guggenheim Fellow at the National Museum); Clyde T. Holliday, Applied Physics Laboratory, Johns Hopkins University, Silver Spring, Maryland; Charles J. Salat, Armour Research Foundation, Chicago; T. G. Rochow, American Cyanimid Company, Stamford, Connecticut; and C. O. Worden, Laboratory of C. A. Zapffe, Baltimore.

In the color division, the following won awards: *First:* Charles D. Oughton and Eugene C. Ricker, Battelle Memorial Institute, Columbus, Ohio, for "Xerographic developing process." *Second:* Chester F. Reather, Carnegie Institution, Baltimore, for "Implantation of 12-day human ovum." *Third:* Thomas C. Poulter, and Walter Lawton, Stanford Research Institute, Stanford, California. *Honorable mention:* D. H. Rowland, Carnegie-Illinois Steel Corporation Research Laboratory, Pittsburgh; R. Stradling, U. S. Pipe and Foundry Company, Burlington, New Jersey; and A. C. Walker and S. O. Jorgensen, Bell Telephone Laboratories, Murray Hill, New Jersey.

The contest, which was established to encourage and extend the use of photography as a basic research tool, will be continued in 1950.

An Italian public health survey is being made under the auspices of the Italian High Commissariat for Hygiene, assisted by the Rockefeller Foundation and the World Health Organization, to help the Italian government reorganize its public health services so as to take advantage of modern scientific methods in the prevention of disease and the maintenance of health. Such fields as tuberculosis, malaria, venereal diseases, maternal and child care, industrial hygiene and public health statistics are being surveyed by specialists lent to the Italian government by WHO and the Rockefeller Foundation. Among the consultants are Julie Backer, of the Central Bureau of Statistics, Oslo; Luigi Carrozzi, of the University of Geneva; Dr. Lembrez, director of Border Health Control for the Marseilles area; and J. E. McCartney, of London. The survey began in June and is expected to be completed late in September. Results will be reported to the special commission headed by Mario Cotellessa, of Italy, and J. B. Grant, director for Europe in the Rockefeller Foundation's International Health Division.

The Roscoe B. Jackson Memorial Laboratory will put into full effect this fall its program of cooperative graduate study which will make its research facilities available without tuition fee to qualified graduate students. Credits may be applied towards M.D. and Ph.D. degrees in biology, zoology, bacteriology, genetics, psychology, and allied fields. Cooperating graduate schools to date include Northwestern University, University of Chicago, University of Illinois, Johns Hopkins University, Harvard University, University of Michigan, Washington University, Cornell University, University of Rochester, Ohio State University, University of Maine, Pennsylvania State College, and Brown University. There are also assistantships available and the laboratory will aid students in securing predoctoral fellowships such as those offered by the National Institutes of Health and the American Cancer Society.

Abstracts of Vitamin Literature, published by the Association of Vitamin Chemists, is available at an annual subscription rate of $3.00 for four quarterly issues. The fee covers cost of handling, printing and mailing; all abstracting, compilations and editing are done on a voluntary basis by association members. The two preceding volumes are available as long as the supply lasts. Subscriptions should be addressed to Irwin Olcott, Dawe's Vitamin Oil Producers, Inc., 4800 South Richmond Street, Chicago 32.

Status of AAAS Meeting Reservations

The early and heavy demand for *single* rooms already indicates a potential shortage of this type of accommodations at the **116th Meeting of the AAAS in New York City,** December 26–31. There are plenty of hotel rooms but many have double or twin beds. Miss Sylvia T. Peltonen, Manager, Housing Bureau, New York Convention and Visitors Bureau, 500 Park Avenue, New York 22, who is in charge of room assignments, urges that, when possible, room reservations be placed by parties of two or more. This also has the advantage of a lower cost per person. Room reservation coupons will appear in the advertising pages of *Science* at frequent intervals.